

IWG4/66	Sharing Analysis in the 15.4-15.7 GHz Band Between Incumbent Services and NGSO MSS Feeder Links in the Earth-to-Space Direction	4/11/95	MCHI
IWG4/67	Final Report of IWG-4 (Feeder Links for MSS Systems Intending to Operate Service Links in the 1-3 GHz MSS Bands	4/13/95	Chairman IWG-4
IWG4/68	Potential Ka-Band Revisions to Interim Report of IWG-4	4/13/95	CSC
IWG4/69	TRW Response to Document IWG-4/61	4/13/95	TRW
IWG4/70	Proposed Changes to IWG-4 Interim Report	4/13/95	Teledesic

**APPENDIX 4.7.2**  
**WRC - 95 Advisory Committee**  
**IWG4 (Feeder Links)**  
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**FCC INDUSTRY ADVISORY COMMITTEE**  
**FOR THE**  
**ITU 1995 WORLD RADIO COMMUNICATION CONFERENCE**

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**FINAL REPORT**  
**OF**  
**INFORMAL WORKING GROUP 5**

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**Diane Garfield**  
**Chair**

**Jack Miller**  
**Vice Chair**

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## **IWG-5 - Science Services Final Report to the IAC**

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## **5. IWG-5: SPACE SERVICES**

### **5.1. Introduction**

#### **5.1.1. The Scope of this Report**

This is the final report to the FCC Industry Advisory Committee (IAC) on the 1995 World Radiocommunication Conference (WRC-95) from Informal Working Group 5, (IWG-5), Space Services. The next WRC is scheduled to convene in Geneva in November of 1995 and will consider a substantive agenda recommended at WRC-93. This report addresses those space service (e.g. space research, space operation, and earth exploration satellite) issues which WRC-93 recommended for inclusion on the WRC-95 agenda. Specifically these include: (1) power limits for earth stations in the 2025-2110 MHz Band; (2) consideration of Resolution 112 (WARC-92) dealing with sharing in the 13.75-14.0 GHz band; and (3) Resolution 712 (WARC-92) dealing with space science service allocation issues not considered at WARC-92.

The purpose of this report is to assist the FCC in developing U.S. positions and proposals for WRC-95 and in recommending the preliminary agenda items for WRC-97 and WRC-99. This report contains the information and comments received to date in IWG-5 which address the technical and regulatory matters relating to the WRC-95 agenda items listed above.

Diane Garfield was appointed Chair of IWG-5 and J. E. Miller was appointed Vice-Chair. Steve Sharkey is the Designated Federal Officer.

#### **5.1.2. Terms of Reference**

The Terms of Reference direct IWG-5 to draft and justify for consideration by the Committee of the Whole, recommendations for U.S. proposals and positions related to:

- (1) Power limits for earth stations in the Earth exploration-satellite, space research, and space operation services in the band 2025-2110 MHz;
- (2) Resolution 112 (WARC-92) concerning the use of the 13.75-14.0 GHz band, in light of the results carried out in application of that resolution;
- (3) Issues considered under Resolution 712 (WARC-92) limited to consideration of work carried out by the study groups and the

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Conference Preparatory Meeting of the Radiocommunication Sector,  
with a view toward action being taken by WRC-97;

- (4) Related space services matters as specified by the WRC-95 agenda and as approved by the Committee of the Whole.

The recommendations for the U.S. proposals and positions related to the above shall be supported by narrative text indicating the rationale for decisions of this group. Potential issues for future conferences shall be referred to IWG-6, Future Agendas, for consideration.

### **5.1.3. Work Program**

The Work Program of IWG-5 directs that when recommending U.S. positions and proposals the committee should consider the following elements:

#### **5.1.3.1. Agenda Item 2.2**

**Power Limits.** The informal working group is to recommend appropriate power limits for earth stations in the space science services (space research, space operations, and earth exploration) allocated to operate on a primary basis in the 2025-2110 MHz band. In recommending power limits, the informal working group is to consider the effects these limits will have on the ability of space science services to share the 2025-2110 MHz band with fixed and mobile services which are also allocated to use this band on a primary basis. Work should not, however, extend to specific sharing issues considered in Resolution 211 (WARC-92). Consideration of Resolution 211 is on the preliminary agenda for WRC-97. The informal working group should identify the effect that use of the 2025-2110 MHz band by the space science services will have on existing or future use of the band by non-government users.

#### **5.1.3.2. Agenda Item 2.3**

**Fixed Satellite Service Use of the Band 13.75 - 14.0 GHz.** The informal working group is to consider Resolution 112 (WARC-92) and develop recommendations concerning use of the 13.75-14.0 GHz band by the fixed satellite service, including the ability of the fixed satellite service to share the 13.75-14.0 GHz band with other services allocated to use this band, both on a primary and a secondary basis. This should include analysis of all relevant resolutions, footnotes, and studies related to this issue. The informal working group should identify the potential non-government use of this band and the effect that sharing with other services will have on non-government use.

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#### **5.1.3.3. Agenda Item 3(b)**

Space Services Allocations. The informal working group is to consider work related to agenda item 3(b) carried out by the study groups and should identify specific related issues or concerns that may require further study prior to action at a future conference. Action on Resolution 712 is on the preliminary agenda for WRC-97. In identifying issues for further study, particular attention should be given to the effect that recommendations of the study groups will have on present or future non-government use of applicable frequency bands.

#### **5.1.3.4. Other Matters**

Any matters that the informal working group believes require further consideration at a future conference but that are not specifically addressed on the WRC-95 agenda or WRC-97 preliminary agenda should be referred to IWG-6, Future Agendas for consideration.

#### **5.1.4. Meetings and Participants**

To date IWG-5 has held eleven meetings. Participation in the group is open to all persons in both the public and private sectors. A list of meeting attendees is included in Appendix 5.6.1. Typical meeting attendance has been on the order of ten persons with the division averaging about seventy percent public and thirty percent private sector attendees. While private sector participation has been less than outstanding, recently a consistent core of private sector participants has emerged who are beginning to take initiative on specific issues of interest.

#### **5.1.5. Report Organization**

This report is organized into six Sections. Section 5.2 deals with the issue of power limits for Earth stations in the 2025-2110 band. This section includes background on the issue and discussion of a position paper which was developed following the results of the Joint Ad Hoc Working Party 7B/9D (JAHWP 7B/9D) meeting in November of 1994.

Section 5.3 addresses Resolution 112 dealing with sharing issues in the 13.75-14.0 GHz band. This section covers the background of sharing difficulties encountered between the services in this band (fixed satellite, radiolocation, radionavigation, Earth exploration-satellite and space research). Recommendations prepared by the ITU-R to

enable sharing between the FSS and systems in the radiolocation and radionavigation service, and to protect space science use of the band are reviewed. Suppression of Resolution 112 is proposed in light of this work. In addition it addresses the one aspect of the suitability of this band as a candidate for MSS feeder links.

Section 5.4 addresses issues considered under resolution 712 (WARC-92). It is intended that these issues be examined at WRC-95 with the understanding that any substantive action is to be taken at WRC-97. This section discusses the issues contained in Resolution 712, the current status of relevant work in the ITU-R study groups, and comment on these issues from the private sector. It is recommended that the specific contents of Resolution 712 be reviewed at WRC-95 with a view to facilitating the work of WRC-97.

Section 5.5 addresses issues for consideration for future conferences. The issue of allocation changes in the frequency range between 50.2 GHz and 71 GHz was introduced for consideration and discussion in IWG-5. The private sector has commented by letter to IWG-5 upon one aspect of this issue, sharing between the Earth exploration-satellite service (EESS) and the intersatellite service (ISS) in the vicinity of 68 GHz. A draft proposal and annex containing the pertinent background and rationale related to this issue were forwarded to IWG-6, for consideration for the WRC-97 agenda.

Draft proposals and position papers are contained in Section 5.6.1. Meeting participants are contained in Section 5.6.2 and a list of IWG-5 documents is in Section 5.6.3.

## **5.2. Power Limits for Earth Stations in the 2025-2110 MHz Band**

### **5.2.1. The Issue**

Agenda item 2.2 of WRC-95 addresses the issue of power limits for earth stations in the space science services that operate in the 2025-2110 MHz band. At the 1992 World Administrative Radio Conference (WARC-92) new primary allocations were added to the International Table of Frequency Allocations for the space research, space operation and Earth exploration-satellite services for the 2025-2110 MHz and 2200-2290 MHz bands. These bands were already allocated on a primary basis to the fixed and mobile services, except in Region 1 where they were secondary. It is worth noting however that in the United States the 2025-2110 MHz band is allocated to the mobile service on a primary basis. Footnote U.S. 90 limits transmissions in the space research and earth Exploration-satellite services.

WARC-92 did not specify any power limits for earth stations in these services, which raised some concern due to the sharing required with the mobile and fixed services. Sharing between earth stations in the space services and the terrestrial services is typically accomplished by limiting the equivalent isotropically radiated power (e.i.r.p.) emitted by the earth stations toward the horizon. Radio Regulations Article 28 No. 2541 provides e.i.r.p. limits for earth stations in the frequency bands between 1 and 15 GHz. The services and associated bands for which these limits apply are specified explicitly in RR No. 2547 (S21.12). The space science services are not listed for the 2025-2110 MHz band.

Various sharing issues, including appropriate e.i.r.p. limits for the space services earth stations in the 2025-2110 MHz band have been under study by JAHW 7B/9D. At the November meeting of JAHWP 7B/9D the opinion was expressed that the power limits necessary to protect existing fixed-service systems operating in this band would be no greater than those given in RR 2541.

### **5.2.2. Other Positions and Proposals**

At WRC-93 the Canadians unsuccessfully proposed application of the No. 2541 e.i.r.p. limits to the space research service. Canada was also instrumental in placing this issue on the WRC-95 agenda. At the March CITEL PCC-III meeting in Isla Margarita, the Canadians expressed their intention to submit a proposal to WRC-95 to apply the values given in RR 2541 to the 2025-2110 MHz band. The U.S. indicated it would support such a proposal. Great Britain, Japan and Russia have all expressed support for

application of the No. 2541 e.i.r.p. limits to earth stations in the space science services operating in this band.

At present, the IRAC is believed to have no plans to submit a proposal on this agenda item.

### **5.2.3. The IWG-5 Position Paper**

IWG-5 has developed a position paper addressing agenda item 2.2. This paper is in response to the conclusions reached in JAHWP 7B/9D. IWG-5 participants support application of the power limits in RR 2541. However, while JAHWP 7B/9D recommends that power limits "no greater than" RR 2541 would be suitable, IWG-5 participants were of the opinion that only the values specified in RR 2541 would be appropriate, as technical studies supporting application of any other values do not exist. The IWG-5 position paper can be found in Section 5.6.1.

In its December Interim Report to the IAC, IWG-5 included a draft proposal addressing agenda item 2.2 in which No. 2544 bis (6) was proposed as an addition to Article 28 of the Radio Regulations. This addition would have established an exception to the power limits given in RR No. 2541 for earth stations in the space science services operating in the 2025-2110 MHz band. This draft proposal was predicated upon the assumption that JAHWP 7B/9D would agree upon a set of technical parameters different from those in RR 2541 which the U.S. could propose to satisfy this agenda item.

Other administrations will likely propose adoption of the RR 2541 values for earth stations in the space science services operating in the 2025-2110 MHz band. For this reason, and because domestic allocations create a somewhat different sharing situation within the U.S., IWG-5 felt it appropriate to replace the draft proposal of the Interim Report with the position paper found in Section 5.6.1.

## **5.3 Resolution 112: Use of the 13.75-14.0 GHz Band**

### **5.3.1. The Issue**

WARC-92 added an allocation to the fixed-satellite service in the frequency band 13.75-14.0 GHz. Radio Regulation 855A places limitations on the fixed-satellite, radiolocation and radionavigation services to enable sharing in the band. Radio Regulation 855B gives equal status to those geostationary space stations in the space research service for which advance publication information had been provided prior to 31 January 1992 and to stations in the fixed-satellite service. It also stipulates that stations in the fixed-satellite service shall not cause harmful interference to non-geostationary space stations in the space research and Earth exploration-satellite services until 1 January 2000.

Resolution 112 invites the ITU-R to study the adequacy of the values given in 855A to enable sharing and to report on its findings at least one year prior to the next competent conference. It also invites studies with regard to the compatibility between systems in the fixed-satellite service and those in the space research and Earth exploration-satellite services. It further calls for review of 855A to be placed on the agenda of the next World Radiocommunication Conference (WRC).

Review of Resolution 112 in the light of the results of studies carried out in application of that Resolution and the taking of appropriate action are Item 2.3 on the Agenda for WRC-95.

A new, related issue has emerged due to consideration of the 13.75-14.0 GHz band as a candidate band for MSS feeder links.

### **5.3.2. Status and Results of Studies**

ITU- R Task Group 4/4 was formed to perform the studies related to the values given in RR 855A. Task Group 4/4 has completed its studies and confirmed the values given in RR 855A to be appropriate to enable sharing the 13.75-14.0 GHz band between the FSS and the radiolocation service. Recommendation ITU-R S.1068 was developed and approved to provide further detail with respect to sharing between the services. Annex 1 of the Recommendation contains the methods and sharing criteria to be used to compute and assess the interference from radars to fixed-satellite service networks. It further recommends that the design of new transmitters in the radiolocation/radionavigation services should be consistent with these sharing criteria.

ITU-R Task Group 7/3 was established to study the technical compatibility between the primary allocation to the fixed-satellite (Earth-to-space) service and the allocations to the space research and Earth exploration-satellite services. It has also completed its studies.

Task Group 7/3 determined that there is limited compatibility between the primary allocation to the FSS (Earth-to-space) and the secondary allocations to the space research service and the Earth exploration-satellite service in the band 13.75-14.0 GHz after the year 2000. Most active sensor operators will choose to redesign their follow-on instruments, beyond those currently in orbit or planned for launch in the near future, to operate below 13.75 GHz, thus avoiding the possibility of interference from the FSS. One long range problem was identified, however, and that is a need to protect the operation of the forward service link of NASA's tracking and data relay network into the 21st century. There is also a need to extend operations of the NASA/NASDA planned TRMM precipitation radar until 1 January 2001 in order to complete its mission.

Task Groups 4/4 and 7/3 worked in close cooperation to develop constraints that will permit completion of the space science missions while allowing early entry of the FSS into the 13.75-14.0 GHz band. Recommendations ITU-R S.1069 and ITU-R SA.1071 contain the agreed constraints on the operation of fixed-satellite networks in order to protect the space science systems to beyond the year 2000.

Task Group 7/3 verified that there is a continuing need for the space science services to operate at frequencies in the vicinity of 14.0 GHz with bandwidths of as much as 500 MHz. It is not necessary that in the future the frequencies available for use by the space science services include the 13.75-14.0 GHz band. However, the reduced band of 13.4-13.75 GHz that will be of practical use to the space science services has a bandwidth of only 350 MHz. This unresolved problem and the related issue of primary status for active sensor allocations is being handled under WRC-95 agenda item 3b, consideration of Resolution 712 (See Section 5.4.2 of this report).

### **5.3.3. IWG-5 Draft Proposal**

Resolution 112 can be suppressed in light of the satisfactory completion of studies carried out by ITU-R Task Groups 4/4 and 7/3 and the adoption of ITU-R Recommendations ITU-R S.1068, ITU-R S.1069 and ITU-R SA.1071. RR 855A and RR 855B should be modified to reflect these results. The IWG-5 draft proposal to accomplish these actions is contained in Section 5.6.1 of this report.

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Considerable discussion took place in IWG-5 with regard to incorporation by reference of the relevant IRU-R Recommendations into RR 855A and 855B. While the general opinion on this subject was that some sort of reference to the ITU-R Recommendations would be useful to readers of the Radio Regulations, no consensus could be reached as to how best to accomplish such a reference. As a compromise, language referring to the relevant ITU-R Recommendations was included in parentheses (e.g., " see Recommendation ITU-R S.1068".)

#### **5.3.4. Suitability of the 13.75-14.0 GHz Band for MSS Feeder Links**

The band 13.75-14.0 GHz has been identified as a possible down-path for feeder links in the Mobile-Satellite Service (MSS). This use would be in the reverse direction to the current allocation for the Fixed-Satellite Service (FSS) (Earth-to-space). The band is also allocated to the radiolocation and radionavigation services on a primary basis and to the space research and Earth exploration-satellite services on a secondary basis. There are potential interference situations that would be created were the band to be allocated for MSS (space-to-Earth) and which have a bearing on the suitability of such an allocation.

##### **5.3.4.1. Interference into Radar Receivers**

Interference into radar receivers has been studied and reported in Documents USWP 4A/3 and USTG 4-5/3. Maintaining interference into radar receivers at an acceptable level would require imposition of an aggregate Power Flux Density (PFD) limit at the surface of the Earth of  $-162 \text{ dB (W/m}^2\text{/4 kHz)}$ . Since coordination is totally impractical for interference into radars, this PFD limit should not be exceeded.

##### **5.3.4.2. Feeder Link Receiving Earth Station Constraints**

Minimum Earth station antenna diameters have been calculated that would conform to a PFD limit of  $-162 \text{ dB (W/m}^2\text{/4 kHz)}$ . It was determined that for a geostationary satellite with a 3 dB coverage contour, the minimum diameter would be 5.26 m. For non-geostationary satellites the minimum diameter depends on a number of factors including the orbit, satellite antenna gain pattern and down-link power control. If the satellite e.i.r.p. is constant with respect to the Earth's surface and the orbit is circular, the minimum antenna diameter ranges from 19.2 m for a 500 km orbit to 5.6 m for a 10,000 km orbit. It is obvious that satellite antenna beam shaping and/or satellite power control would be required in order to meet the PFD limits with reasonable size Earth station antennas.

#### **5.3.4.3. Radar Interference into Feeder Link Earth Stations**

High power radars on ships operate in this band. Lower power radars are land based and/or carried on aircraft. It appears that feeder link Earth stations can be protected from interference from ship radars but only by provision of adequate site shielding between a feeder link Earth station and navigable waters.

There is also a potential for interference from land based or aircraft based radars. The degree of interference is dependent on a highly localized environment and would have to be assessed on a case-by-case basis.

#### **5.3.4.4. Interference into Space Science Networks**

RR 855B provides protection for low orbiting satellites in the Earth exploration-satellite and space research services until 1 January 2000. The potential for harmful interference into these satellites has not been evaluated but would need to be taken into account in any near-term plans to implement feeder links for the MSS. A longer term situation is the need to continue to operate NASA's Tracking and Data Relay Satellite System into the 21st century. The potential for interference into the forward links of this system needs to be assessed as part of an evaluation of the suitability of the 13.75-14.0 GHz band for MSS feeder links.

#### **5.3.4.5. Assessment**

A requirement to coordinate between radars and the MSS could not be accepted by radar operators.

Imposition of a PFD limit could preclude unacceptable interference into radars. However, the necessary limit would impose significant limitations on the minimum Earth station antenna sizes that could be used by the MSS.

Unacceptable interference into feeder link Earth stations caused by ship based radars can be virtually eliminated through use of appropriate siting and shielding of the Earth station. The likelihood of interference from land based and aircraft based radars is more problematical and depends on localized conditions that would require case-by-case evaluation.

The potential for unacceptable interference from MSS feeder links to space science systems has not been analyzed but needs to be taken into account.



From a U.S. position standpoint, the WARC-92 objective still applies, i.e., to minimize the use of the 13.75-14.0 GHz band by the FSS, including feeder links. ITU-R studies and Recommendations were based on statistical analyses. Increasing FSS usage of the band increases the probability of mutually unacceptable interference. The U.S. position opposes allocation of this band for MSS feeder links using reverse band working.

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## **5.4. Issues Considered Under Resolution 712**

### **5.4.1. The Issues**

Agenda item 3 for WRC-95 instructs the conference to consider Resolution 712 (WARC-92), taking into account the work carried out by the study groups and the Conference Preparatory Meeting (CPM) of the Radiocommunication Sector, with a view to WRC-97 taking action, as appropriate. Resolution 712 was adopted at WARC-92 and placed on the WRC-95 agenda at WRC-93. It directs the conference to consider the following matters relating to allocations for the space science services:

- (1) use of existing allocations in the 8-20 GHz range to the Earth exploration-satellite and space research services, with a view to establishing common world-wide primary allocations to these services in appropriate bands;
- (2) additional inter-satellite service requirements for up to 50 MHz of spectrum near 23 GHz;
- (3) provision of up to 1 GHz of frequency spectrum around 35 GHz for use by space-based active earth sensors;
- (4) inclusion of CCIR-approved technical coordination parameters in Appendix 28 of the Radio Regulations.

It is understood that the examination of these issues at WRC-95 will be limited to consideration of the work carried out to date by the various study groups. However, CPM-95 has suggested that the specific contents of Resolution 712 be reviewed in light of studies in progress at this time with a view to facilitating the work of WRC-97. Any necessary action will be taken at WRC-97 as part of that conference's overall consideration of space science issues. Each of these issues is elaborated below.

### **5.4.2. Earth Exploration-Satellite and Space Research Satellite Service Allocations in the 8-20 GHz Range**

#### **5.4.2.1. Active Space-Based Sensor Allocations**

Allocations for use by active space-based sensors are for the most part by footnote. In the 8-20 GHz range, only one allocation, 17.2-17.3 is in the Table of Frequency

Allocations. Consequently most active sensor allocations are not visible in a cursory review of the Table. Moreover, in most cases where allocations do exist, they are secondary in status, and in all cases are shared with (primary) terrestrial radiolocation or radionavigation services. At recent radio conferences (i.e. WARC-92) the radiolocation and radionavigation service allocations have been seen as vulnerable targets by spectrum seekers in search of new allocations (e.g. 13.75-14.0 GHz and 24.25-25.25 GHz.) In this environment, the future viability of active sensing from space is in jeopardy.

With the majority of space-based sensor allocations being invisible due to their allocation by footnote, they do not offer an effective deterrent to those seeking new and vulnerable targets. Once a band has been targeted by users seeking new spectrum, the defensive battle fought by space-based users is usually a losing proposition. Much greater protection could be afforded to both radiolocation, radionavigation and active space-based sensor systems if they were accorded joint primary status in the Table; neither would be easily overlooked by spectrum seekers.

Consideration of upgraded allocations for active spaceborne sensors in the frequency range spanned by Resolution 712 is appropriate at WRC-97. These bands include 8500-8650 MHz, 9500-9800 MHz, 13.25-13.4 GHz, 13.4-13.75 GHz and 17.2-17.3 GHz. The feasibility of primary allocations in common frequency bands for both active spaceborne sensors and radionavigation and radiolocation services requires that systems be compatible without the necessity for constraints on any of the services. ITU-R Joint Working Party (JWP) 7/8R was established to study the compatibility between active spaceborne sensors and systems in the radiolocation and radionavigation services. At the first meeting (9-11 November) the primary frequency bands considered were those included in Resolution 712. Notable progress was made in examining the feasibility of sharing without restriction between active space-based Earth sensors and radiolocation and radionavigation services in the frequency bands 13.25-13.4 GHz, 13.4-13.75 GHz and 9500-9800 MHz. The JWP has prepared a report to CPM-95 which presents the status of work to date and defines the work that remains to be done. The JWP has prepared a work program that should ensure that its assigned work will be completed in 1996 and the results available to CPM-97.

#### **5.4.2.2. Passive Sensor Allocations**

The Earth exploration-satellite (passive) allocation status in the 18.6-18.8 GHz band is primary in Region 2 and secondary in Regions 1 and 3. This band is one of several frequency bands which are critical for performing ecologically important simultaneous

measurements of land and ocean surface phenomena.\* It is being implemented on an increasing number of Earth exploration satellites. The 18.6-18.8 GHz band is mentioned specifically in considerings "d" of Resolution 712 and consideration of an upgrade to a uniform, worldwide primary status is appropriate.

The feasibility of sharing among the services allocated to use the band (fixed, fixed-satellite, mobile, Earth exploration-satellite and space research) depends upon adoption of constraints on the technical parameters of fixed, fixed-satellite and mobile systems. Suitable constraints are included in the U.S. domestic allocation tables. Sharing criteria for the space science services sharing with the fixed and fixed-satellite services have been developed and considered in ITU-R WP 7C and are presented in its report to CPM-95. Additional studies are underway in WP 7C with results expected to be available for consideration at the time of CPM-97. CPM-95 has recommended attention to studies called for in Recommendation 706, (i.e., sharing between the fixed, fixed-satellite and Earth exploration-satellite services) as an urgent matter.

There are two other passive sensor allocations in the frequency range 8-20 GHz: 10.6-10.7 GHz and 15.2-15.4 GHz. While these bands should be reviewed with regard to allocation status and interference and sharing criteria, there has been no suggestion that these are inadequate for the requirements identified to date. A proposal to modify any of these allocations is not anticipated.

#### **5.4.2.3. Non-Sensor Allocations**

The 8025-8400 MHz communication band is the only band available for wideband EESS data downlinking below 65 GHz. It is vital to both government and non-government users. Unfortunately the Earth exploration-satellite (space-to-Earth) allocation at 8025-8400 MHz is complex and non-uniform worldwide. Only in Region 2 is the EESS allocation primary. In Regions 1 and 3 EESS is a secondary service, although in certain countries it is primary subject to the provisions of Article 14. In terms of allocated services however, the sharing situation in all three regions is identical. Moreover, telemetry data from Earth sensing satellites has been successfully transmitted to Earth in all three regions for many years.

This band is specified in considerings "b" of Resolution 712 and consideration of an upgrade to a uniform, worldwide primary status is appropriate. Its current allocation

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\* Simultaneous measurements are required to isolate individual phenomena from the composite phenomena resulting from multiple effects. Microwave radiance measurements are used to infer: extent, concentration and age of sea ice; water vapour content over the oceans; rainfall over land and/or oceans; and snow cover over land.

status was achieved at WARC-79 and most of the sharing criteria were developed prior to that time. Updated sharing parameters were recently published in ITU-R Recommendation IS.849-1 and these should be incorporated into Appendix 28 of the Radio Regulations (see Section 5.4.5.)

The frequency bands 12.75-13.25 GHz (space-to-Earth) and 16.6-17.1 GHz (Earth-to-space) are allocated to the space research service restricted to deep space operation only in each band. Technical studies have shown that the bands in the vicinity of 32-34 GHz are more suitable for deep space operations. Moreover, the sharing situation at 13 and 17 GHz would be simpler with space research operations not limited to deep space, i.e., if the deep space restriction were removed and the less stringent non-deep space criteria were to be applied. If the band were also considered for upgrade to primary status in addition to removing the deep space restriction, the issue could be treated under Resolution 712 at WRC-97. Studies are underway to demonstrate the improved sharing which will result from such a modification and will be submitted to the CPM and ITU-R study groups.

#### **5.4.3. Inter-satellite Service Allocation Near 23 GHz**

Considerings "e" of Resolution 712 stated that the current inter-satellite service allocation at 22.55-23.55 GHz was insufficient to ensure full interoperability between data relay satellite systems. An allocation of an additional 50 MHz of spectrum had been proposed at 23.55-23.6 GHz. NASA has indicated that it is no longer interested in an additional Inter-satellite service allocation at 23.55-23.6 GHz. The proposed allocation has proven to be incompatible with the adjacent passive sensor allocation at 23.6-24.0 GHz. Moreover, recent channel plans coordinated with all planned data relay satellite systems in the 22.55-23.55 GHz band indicate that the current allocation is sufficient to address known requirements. However reasonable e.i.r.p. limits will be needed to assure compatibility of intersatellite and terrestrial microwave applications.

The band 22.55-23.55 GHz is shared among data relay satellite systems, terrestrial microwave systems, and LEO mobile satellite systems operating crosslinks in the inter-satellite service. It has been noted that band segmentation is a feasible approach to the sharing situation. If all MSS systems could be accommodated in the 22.55-22.81 GHz range, then the current and future data relay satellite requirements could be satisfied in the 22.81-23.55 GHz range.

#### **5.4.4. 1 GHz Spectrum Allocation Near 35 GHz**

In the 35 GHz region, future requirements for active Earth-sensing have been identified for monitoring environmental data. The 100 MHz bandwidth available in the existing allocation at 35.5-35.6 GHz is insufficient to accommodate these requirements. Up to 1 GHz of spectrum for space-based active earth sensors in the vicinity of 35 GHz has been suggested to meet these future needs. Recent developments in active sensing technology and studies underway in WP 7C suggest that bandwidths of less than 1 GHz may be adequate to meet future requirements; 500 MHz may be sufficient. The study is expected to be completed in 1996 and the output available to CPM-97.

#### **5.4.5. Technical Coordination Parameters in Appendix 28 of the Radio Regulations**

Studies concerning the technical coordination parameters for inclusion in the Radio Regulations have been completed. ITU-R Recommendations IS.847, IS.848, IS.849-1, and IS.850 contain the results of these studies and the parameters which should be included in Appendix 28 of the Radio Regulations.

#### **5.4.6. Comments Received to Date in IWG-5**

To date, IWG-5 has received written comment on one of the issues in Resolution 712. Orbital Sciences Corporation ("Orbital") has submitted a paper supporting all efforts for a worldwide upgrade to the Earth exploration-satellite service allocation in the 8025-8400 MHz band and has recommended that IWG-5 support a similar recommendation by NASA to the IRAC. Lockheed had indicated support for the same issue but to date no paper has been submitted. The Orbital paper [IWG-5/36] is contained in Section 5.6.1.

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## 5.5. Issues for Future Conferences

### 5.5.1. Introduction

As discussed in Section 5.5 of the IWG-5 Interim Report to the IAC, several additional space service issues had been introduced into IWG-5 for consideration as candidates for future conference agendas. These issues were forwarded to IWG-6 in a liaison statement explaining that they were under consideration in IWG-5, might be appropriate for inclusion on a future conference agenda, and, if sufficient support were to arise in IWG-5, a proposal to this effect could result. These issues were:

- (1) Upgrade of the allocation status to space research service in the band 410-420 MHz;
- (2) Review of the allocations status for active space-based sensors;
- (3) Adoption of sharing criteria to support space science service operations in the 2025-2110 and 2200-2290 MHz bands;
- (4) Allocation changes in the vicinity of 60 GHz including a new primary allocation to the intersatellite service in the 65-71 GHz band.

At this time, item (4) has generated sufficient support in IWG-5 to result in a draft proposal for an addition to the WRC-97 agenda. The draft proposal and text containing the supporting rationale were forwarded to IWG-6 in another liaison statement of 13 February. This draft proposal recommends adding the following items under agenda item 3.2 of the WRC-97 agenda:

3.2 other frequency allocation issues for the space science services which are not covered in the above-mentioned Resolutions, as follows:

3.2.x review and realign, as appropriate, the existing allocations in the frequency range 50.2-65 GHz with a view to establishing better sharing conditions for allocated services;

3.2.y allocate, on a primary basis, of up to 6 GHz of spectrum, around 68 GHz, to the inter-satellite service.

## **5.5.2. The Issues**

### **5.5.2.1. Atmospheric Temperature Measurements**

Unique oxygen absorption lines exist in the frequency bands between 50.2 and 65.0 GHz. Recognizing the value of this singular scientific resource, WARC-79 allocated the bands 50.2-50.4 GHz and 51.4-59.0 GHz to the Earth exploration-satellite service (passive) to be used for the atmospheric temperature measurements necessary for weather forecasting and climate studies.\* Unfortunately, some of the bands, specifically 50.2-50.4 GHz and 54.25-58.2 GHz are not allocated on an exclusive basis but rather are shared with active radio services.

Since 1979 the science of atmospheric temperature measurement has been significantly advanced. Meteorological organizations have found that the allocations in the range 50.2-66.0 GHz are not optimum for this purpose and cannot provide temperature data in the mesosphere. A band between 60.3 and 61.3 GHz has been identified as necessary for mesospheric temperature measurements. Moreover, the 51.4-52.6 GHz band which is now allocated on an exclusive basis for passive sensing has been found to be unnecessary for atmospheric temperature sounding.

A second factor affecting the potential for shared use of frequency bands is the development of new sensor technology. A new class of passive "pushbroom" sensors is expected to achieve greater measurement sensitivity but at the expense of increased susceptibility to interference relative to conventional scanned sensors.

Sharing studies which were performed prior to the 1979 WARC were based on projected characteristics for undeveloped equipment which was extrapolated from analogous equipment in lower frequency bands. Actual developments in both atmospheric science and sensor technology have resulted in significant variance from these projections. Thus, certain adjustments in allocations to optimize use of this spectrum would be in order and would benefit all of the allocated services.

### **5.5.2.2. LEO Fixed-Satellite Crosslinks**

The band 54.25-58.2 GHz is allocated to the inter-satellite service and may be used by satellite systems for intersatellite links (ISLs) i.e. crosslinks which interconnect one or more satellites in a constellation. This same band is also allocated on a co-primary basis

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\* The World Meteorological Organization (WMO) has a requirement for atmospheric temperature profiles to be produced to an accuracy of 1 Kelvin at altitude intervals of 1 kilometer.



to the Earth exploration-satellite (passive), the space research (passive), the fixed, and the mobile services. At the time of this allocation in 1979 it was envisioned that the ISS would consist of links between geostationary fixed-satellites and a few links between geostationary satellites and LEO satellites.

Today one Low Earth Orbiting (LEO) satellite commercial system is considering use of the intersatellite allocation in the 56.75-57.75 and 59.0-60.0 GHz bands to implement satellite-to-satellite crosslinks among as many as 840 LEO fixed-satellites, and to provide message routings between multiple points on the earth. This system will require bandwidths on the order of 1 GHz in each of the transmit and receive directions initially, with predicted requirements growing to 3 GHz in the foreseeable future.

Additional LEO satellite commercial providers are expected to file for FCC licensing in the near future. The anticipated large number of active transmitters in Low Earth Orbit have the potential to interfere with the passive earth sensors operating in the 54.25-58.2 GHz band. This use, coupled with use of the band by terrestrial fixed and mobile services could render the band unusable for atmospheric sensing measurements by the Earth exploration-satellite service (EESS). The conclusion that sharing is generally possible between the ISS and passive spaceborne sensors is no longer valid. The band 65.0-71.0 GHz has been proposed as a useful alternative for commercial LEO crosslinks.

#### **5.5.2.3. Fixed Service Developments**

The Europeans are now preparing specifications for fixed service systems in the 54.25-58.2 GHz band. As in the ISS case, these systems are expected to differ considerably from what was foreseen in 1979, due in large part to the orders-of-magnitude greater number of transmitters than the radio relay systems anticipated in the 1979 projections. This issue has been studied by the Conference of European Posts and Telegraphs (CEPT) and the Space Frequency Coordination Group (SFCG) which both found incompatibilities in certain frequency ranges that would require constraints on fixed service parameters to resolve. Both groups have recommended some realignment of allocations to avoid placing such constraints on evolving fixed systems and to avoid interference to the passive sensors operating in these bands.

#### **5.5.3. Summary of Proposed Allocation Changes**

WRC-97 provides a timely opportunity to bring allocations in the 50.2-71.0 GHz range into harmony with the needs of the services which use these bands. To enable vital atmospheric temperature measurement to continue without interference, while simultaneously removing the need for constraints on the parameters of emerging fixed and inter-satellite systems, the following allocation changes have been proposed: